NLC GEANT3 Simulation

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Introduction

- GEANT3 is the standard Fortran-based High Energy Physics Detector simulation package
  - Documented
  - Supported
  - Debugged
  - Large HEP User Base
- Offering
  - 2-d and 3-d Graphics
  - Ray Traces
  - Output files (n-tuples, ascii) for detailed post-analysis
- With
  - TURTLE-like tracking
  - Full complement of interactions
    - MCS, dE/dx, $eZ \rightarrow eZ\gamma$, $eZ \rightarrow eZe^+e^-$, $eN \rightarrow eX$
    - Synchrotron Radiation (switch-able)
    - Hadronic Interactions (but poorly done, no neutrons)
  - Flexible materials data base

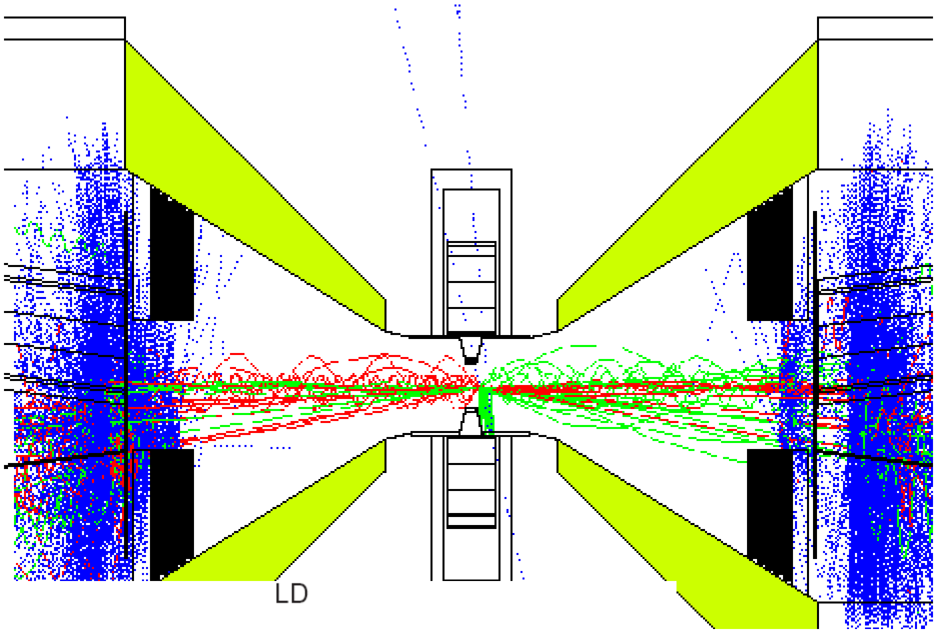
Detector Simulation

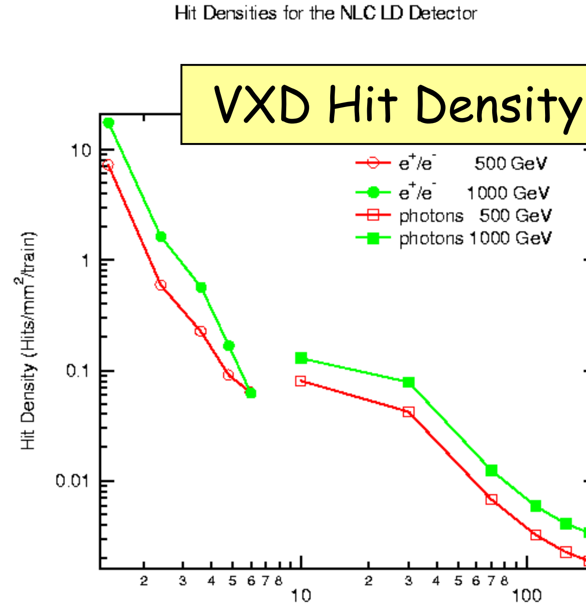
The Normal Application

NLC: "GEANT 3"

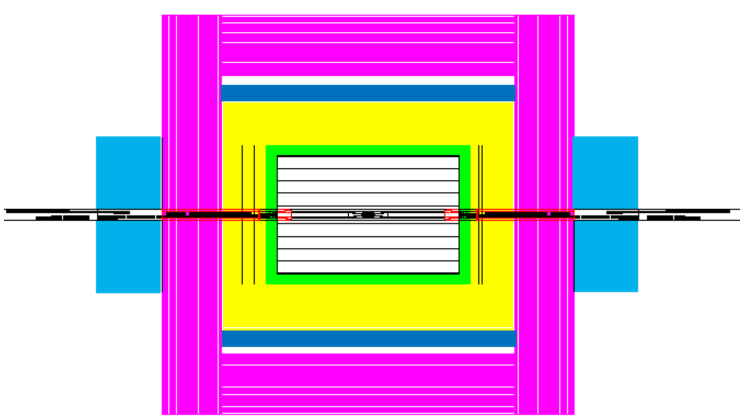
TESLA: "Brahms"

JLC: "JIM"

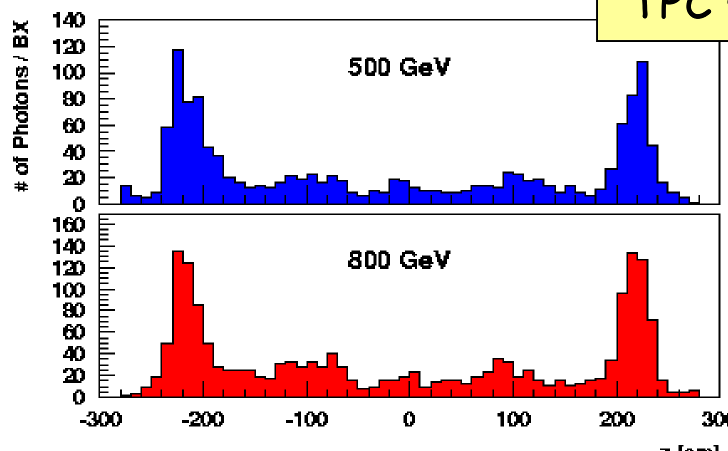




VXD Hit Density



TPC γ Distribution



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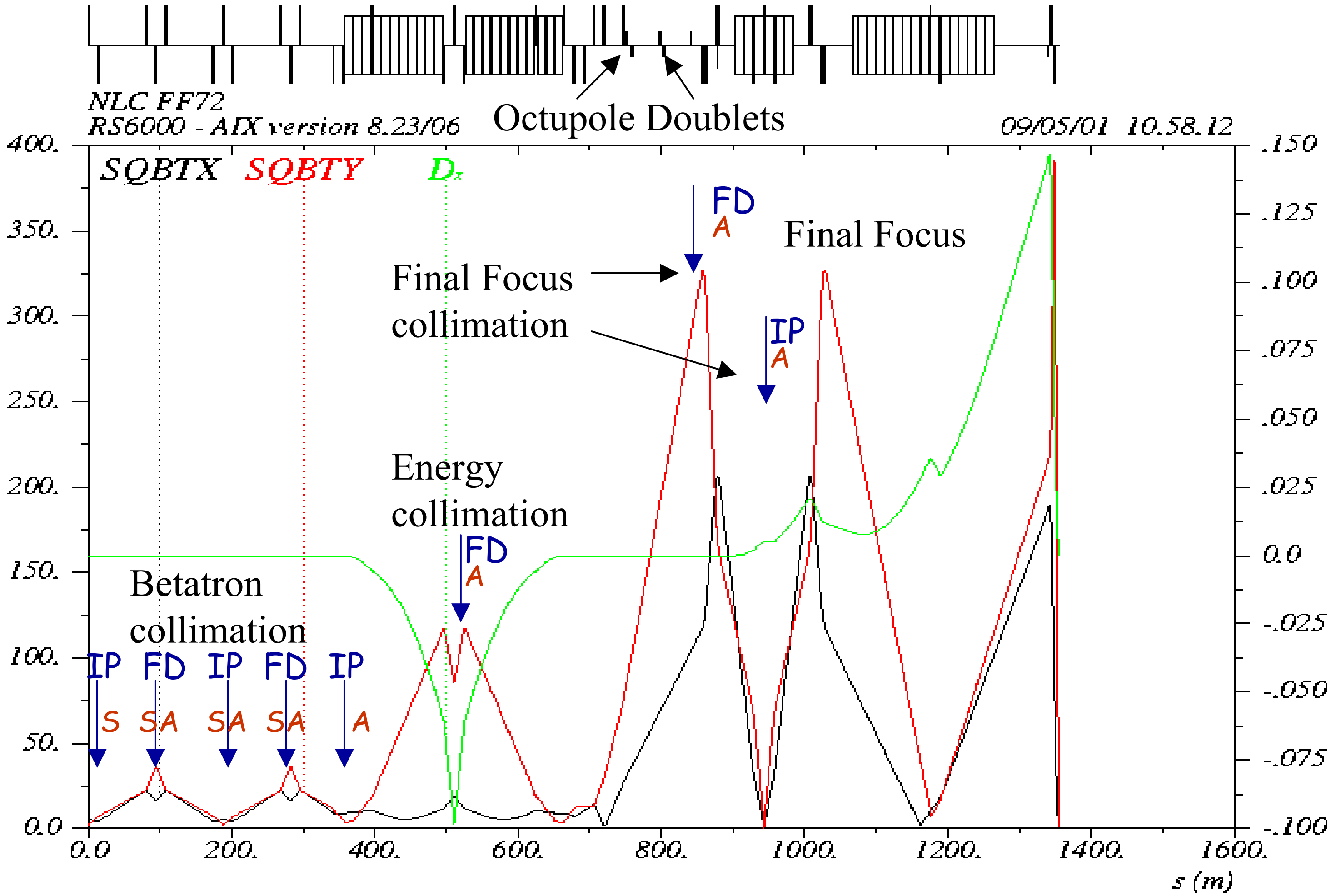
Why is this interesting?

- While a huge number of tracking programs exist
  - TRANSPORT
  - TURTLE, Decay-TURTLE
  - MAD, DiMAD
  - Homebrews:
    - A. Drozhdin: STRUCT
    - S. Hertzbach: QSRAD
    - L. Keller: MuCarlo
- GEANT offers possibility of
  - Interfacing the detector to the beamline
  - Interfacing the experimental physicist to the machine design

What has been done?

- Vanilla GEANT3 from CERN
- Double Precision Version: Paul LeBrun/ FNAL
  - 1nm beam positions and 10km beamlines require DP
- Beamline Interface Package by T. Maruyama
  - MAD deck processed to ASCII magnet file
    - Mag Type, Pole Tip B, Aperture, L , x, y, z, x', y', z'
    - Dipole, Quad, Sext, Oct recognized (for now)
  - User routines made DP: FLD, GuSTEP, UGeom, …
  - Routine to read magnet file
    - Map field and magnets to "lab" coor. System
  - Routine to read file of collimation devices
    - Generate array of "scoring planes"
    - Specify structure of output "n-tuple"

2001 Collimation System & FF integrated design



New scheme of the Collimation Section and Final Focus with ODs

NLC Beam Delivery in Geant 3

TRANSPORT lattice

↓

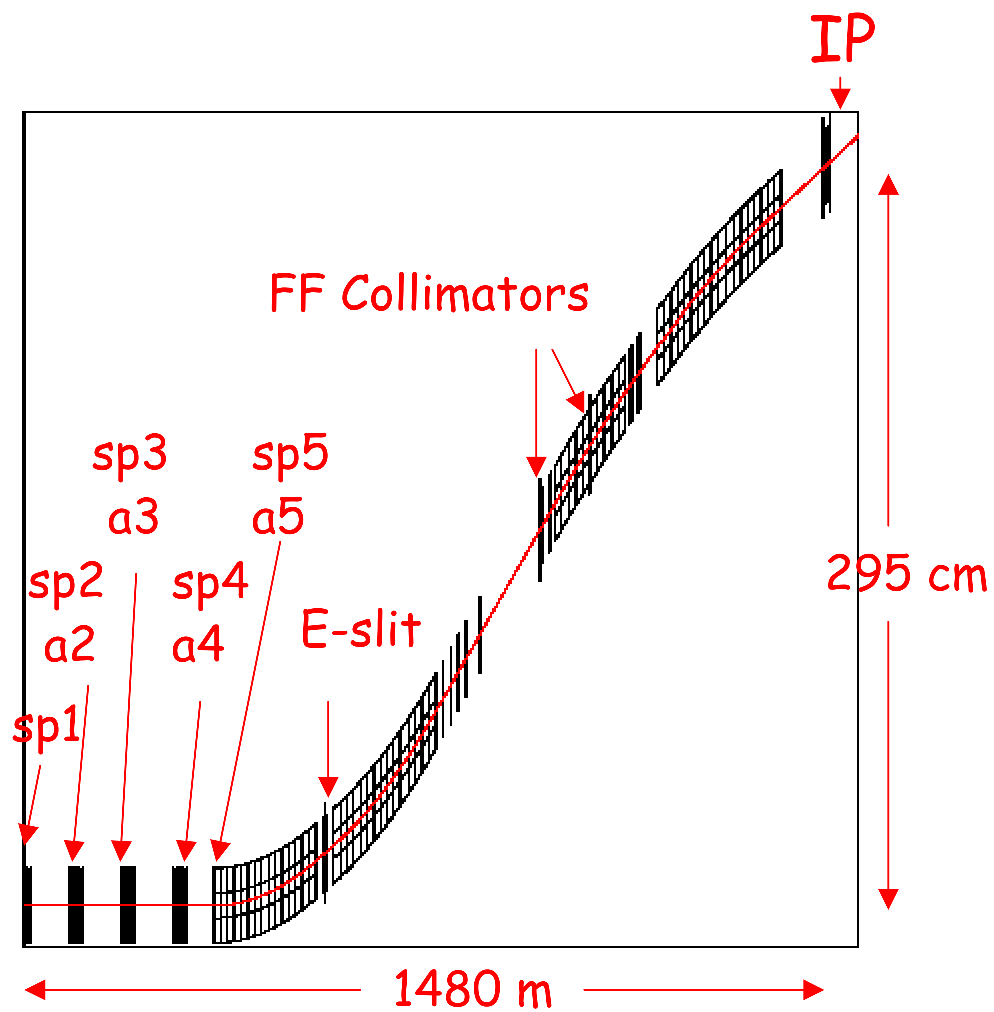
Magnets (bands,quads, sexts, octs)

location, orientation, length, field strength, aperture

Spoilers and Absorbers

↓

Geant 3



Nominal beam into BDS

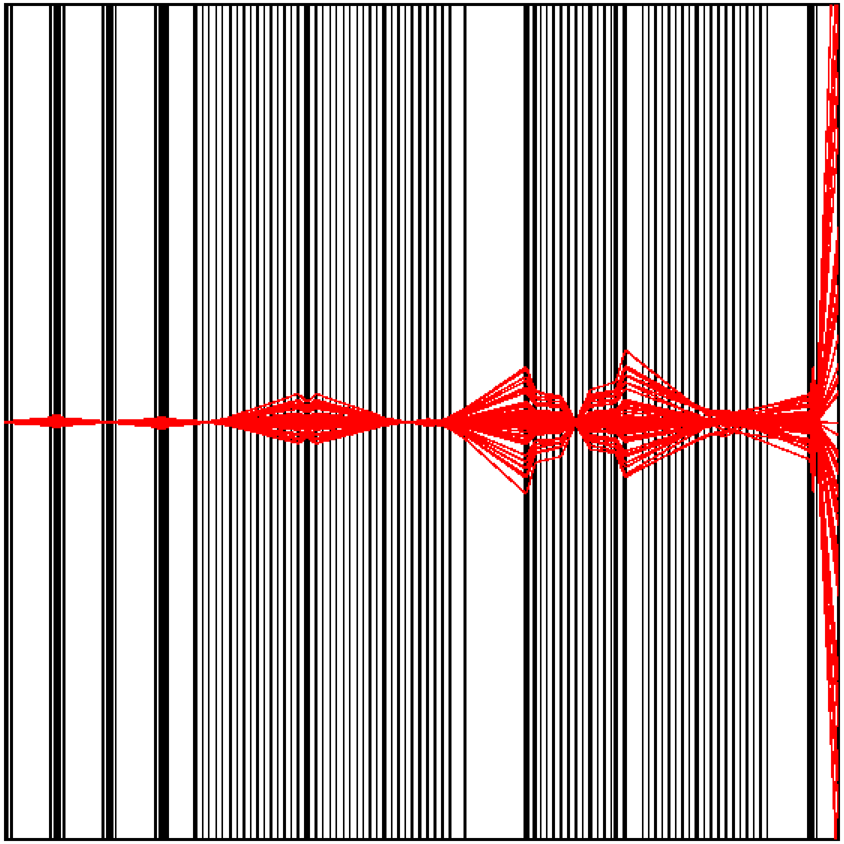
$\sigma x = 10\ \mu m$

$\sigma x' = 0.3\ \mu rad$

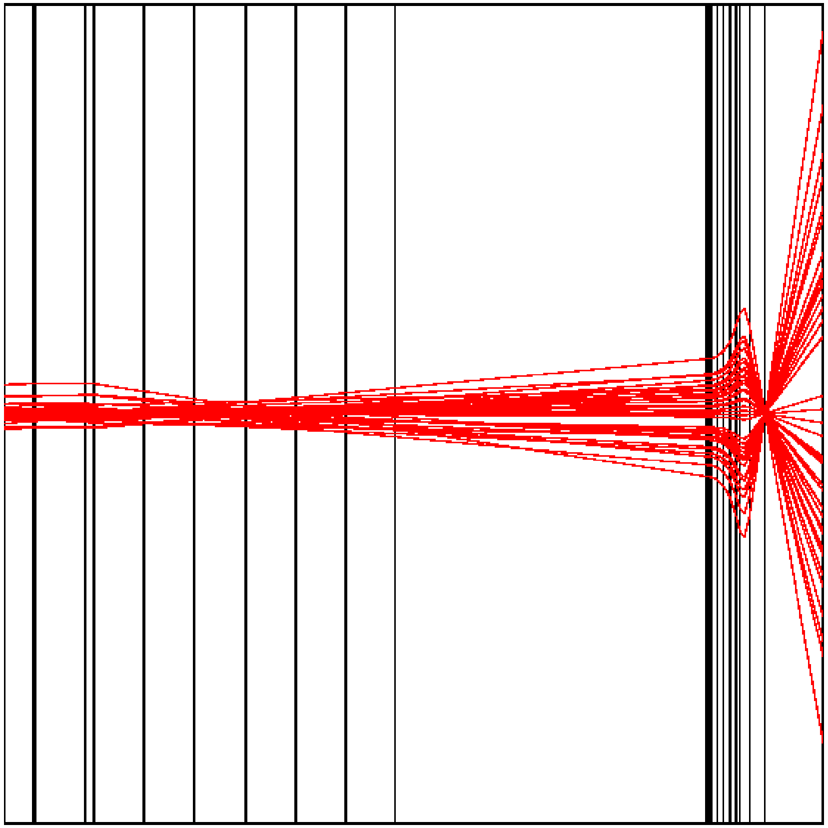
$\sigma y = 0.4\ \mu m$

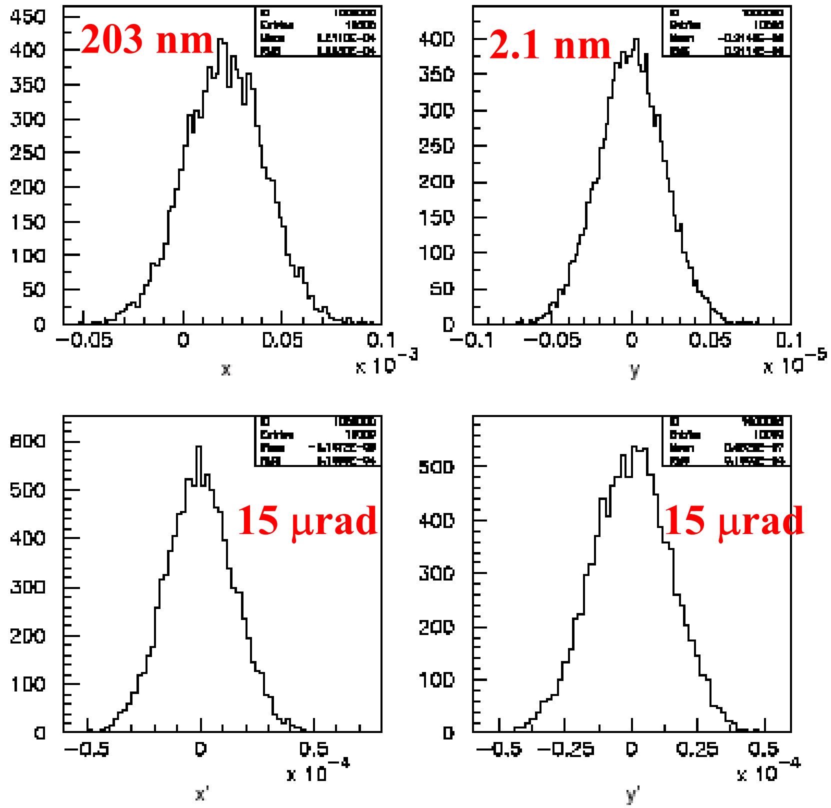
$\sigma y' = 0.075\ \mu rad$

$\Delta E/E = 3 \times 10^{-3}$



500 GeV Beam focuses at the IP

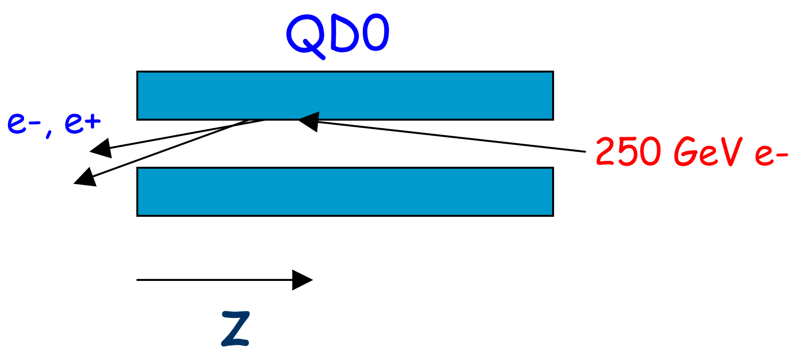


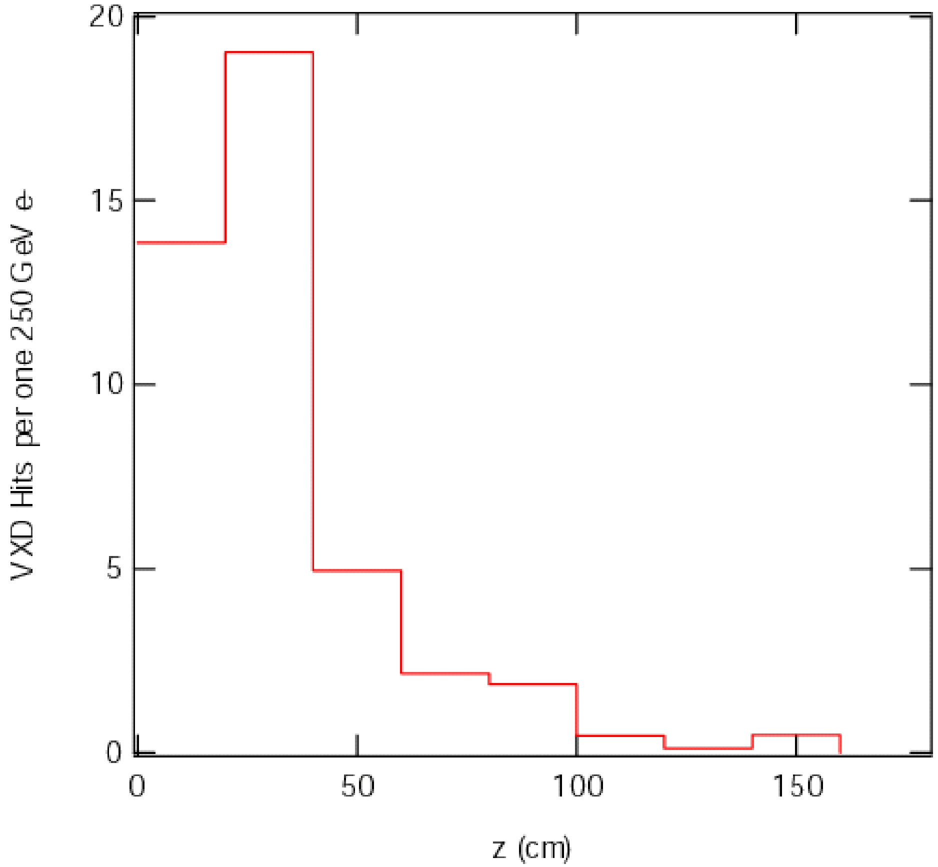


GEANT Features

- Rescattering
  - Secondaries tracked as well
- Energy Deposition
- SR
- Control of detail: E_{cutoff}
  - Set high (90% E_{beam}) to count scatters
  - Set low to study energy deposited
    - 10 keV for γ
    - 1 MeV for e
- One-to-Many Output structure
  - One primary can make an arbitrarily large number of hits in a device
- Problems: Inefficient to populate tails

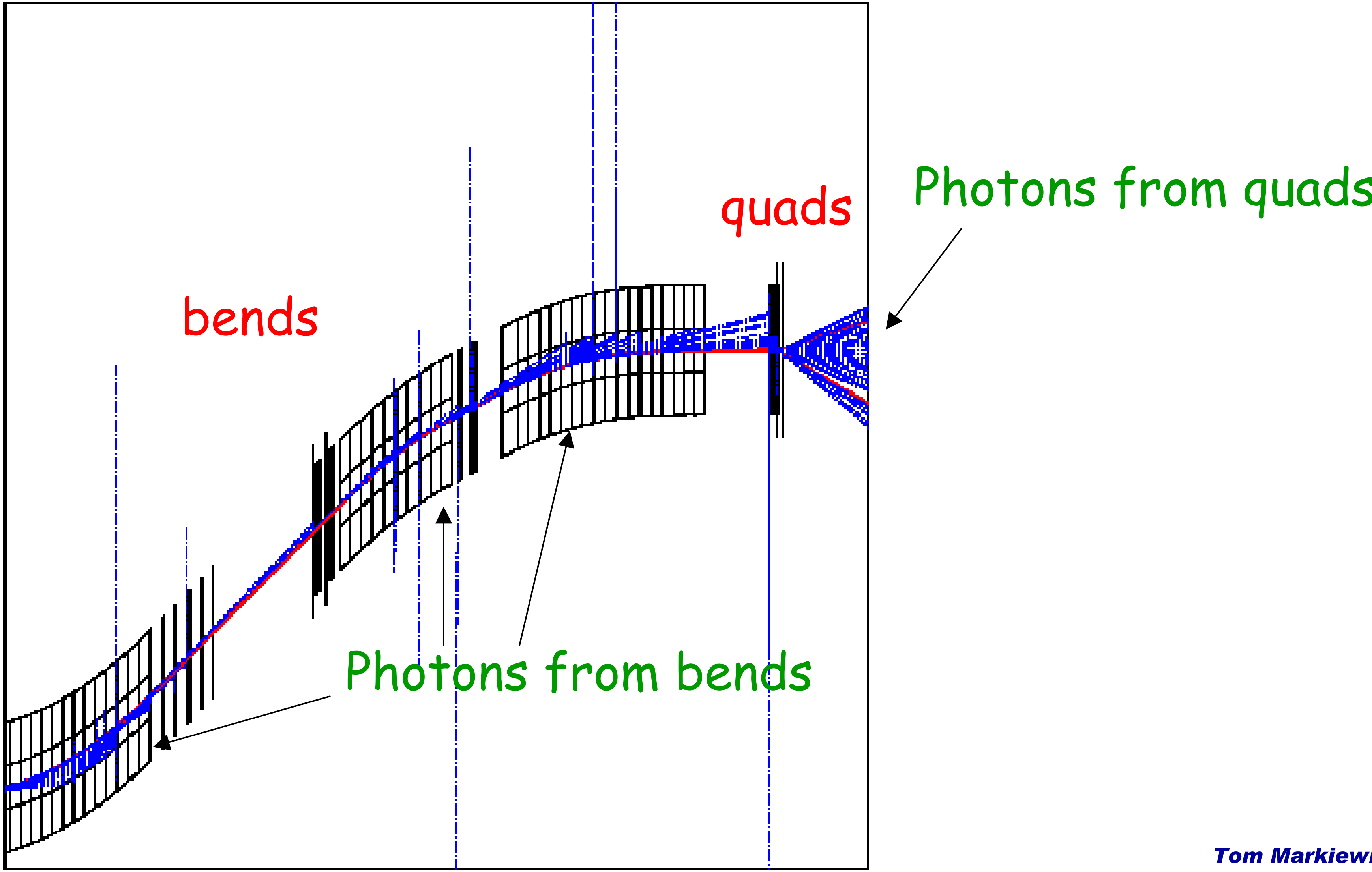
VXD Hits from 250 GeV e- hitting QD0





Z of hit from IP face of QD0

Synchrotron Radiation



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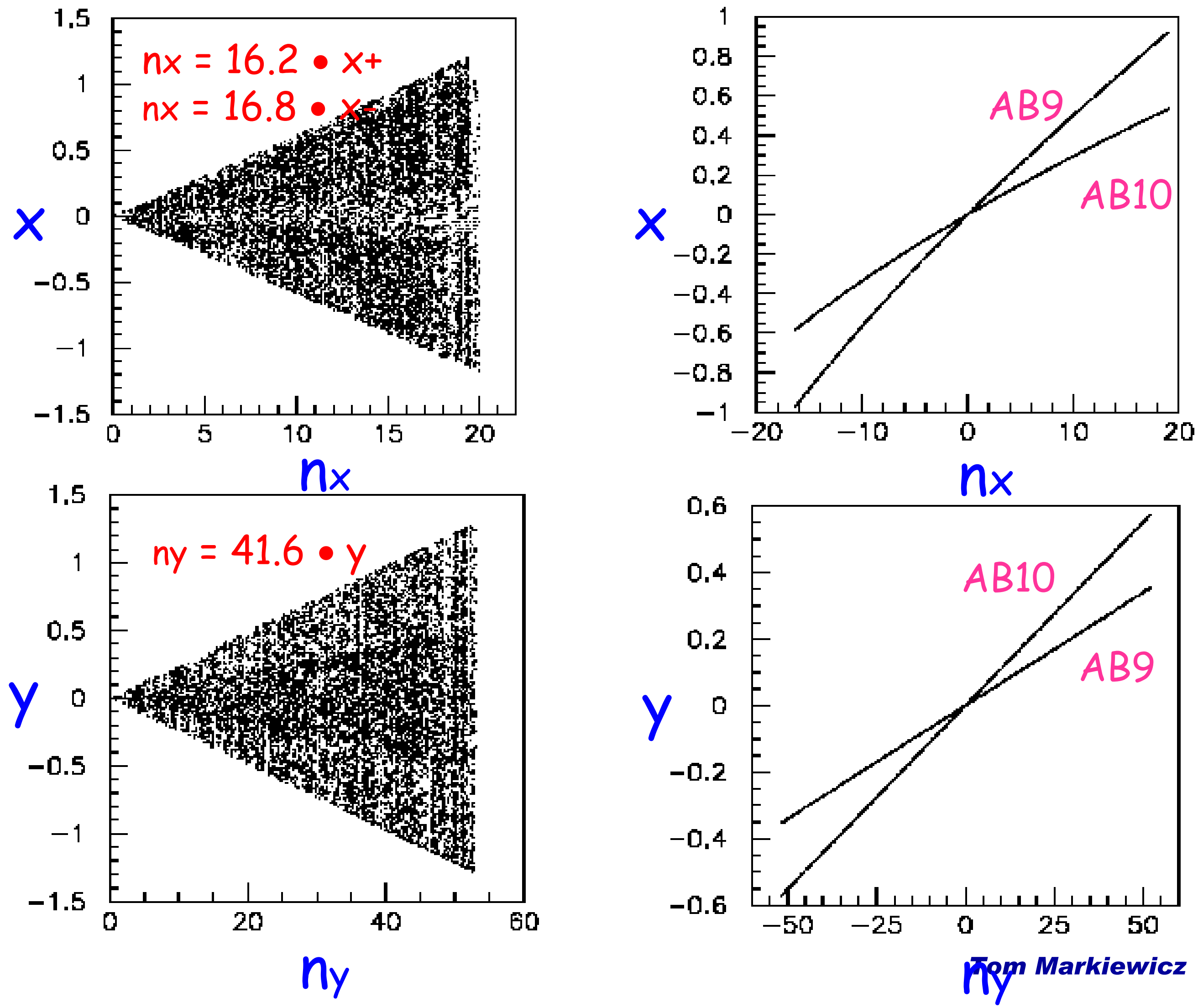
Sync. radiation at Luminosity Monitor (limiting aperture at z = -350 cm) vs. Apertures at AB10 & AB9

- Track particle with n•σ backward from IP to AB10.
- Track particle to IP and generate sync. radiations.
- Find sync. radiation edge as a function of (nx, ny).

  nx = 18.5 • x^+,
  = 17.2 • x^-
  ny = 50.9 • y
- Find AB10 and AB9 apertures as a function of (nx, ny)



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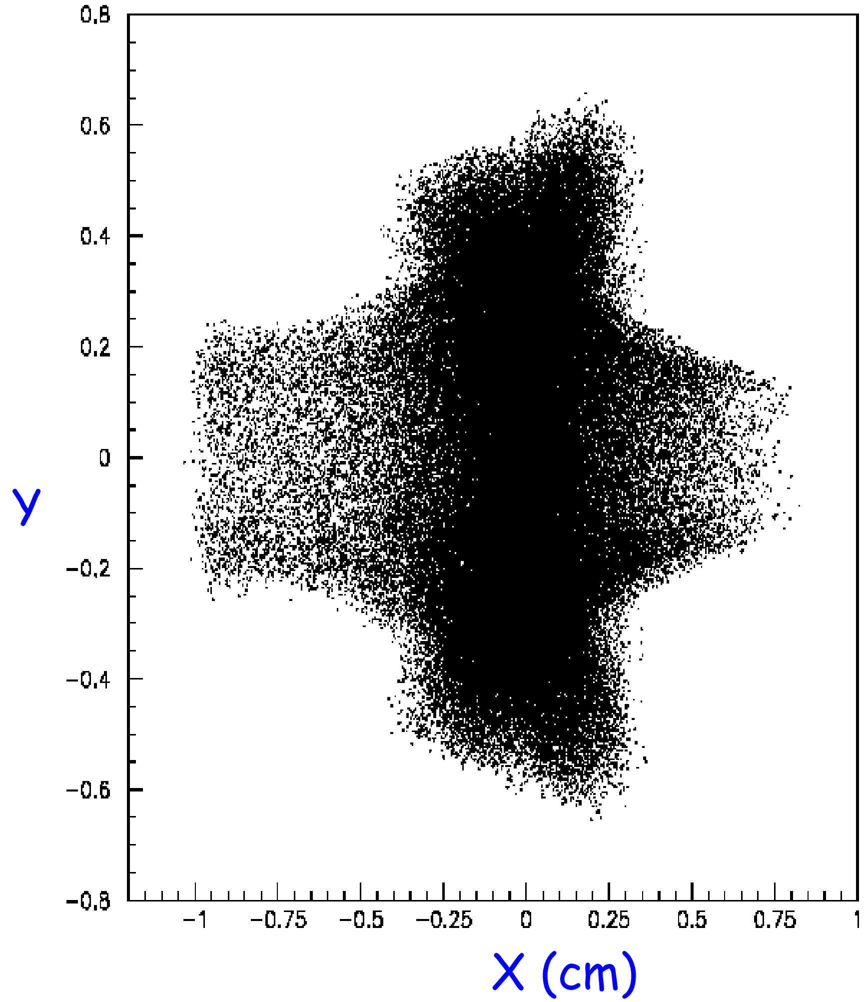
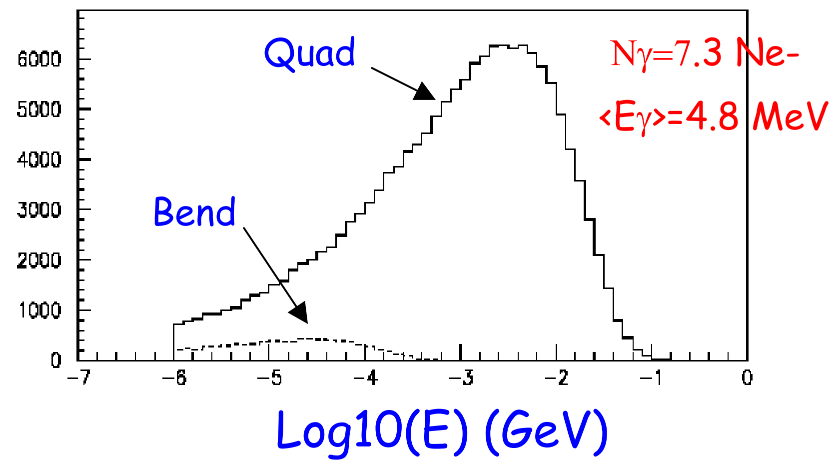
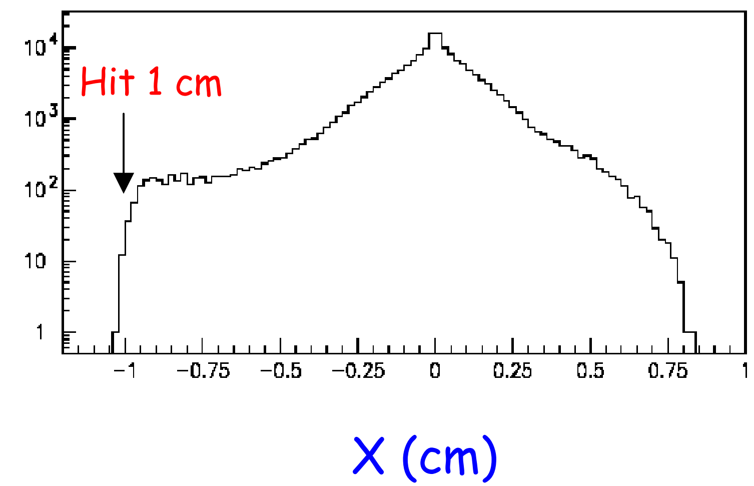
Sync. Radiation at IP







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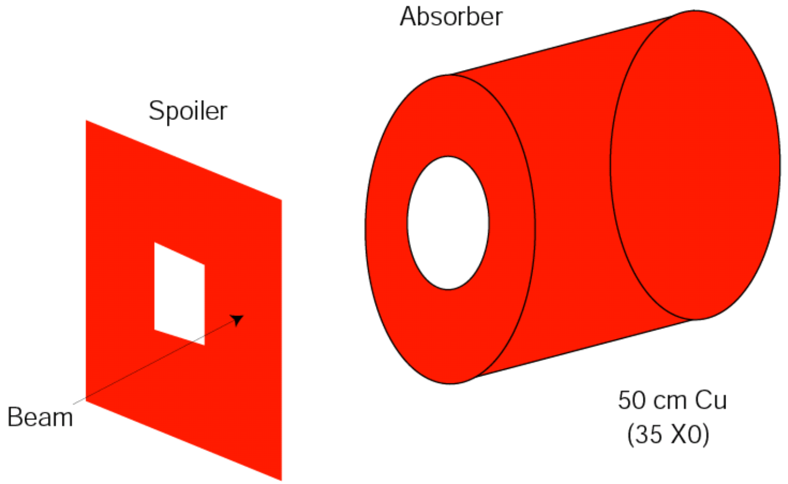
Spoiler/Absorber Scattering



ESP 1.43 cm Cu
(1.0 X0)

ESP 0.5 X0 ~x5 beamloss

Spoilers/Absorbers Settings for NO OCT

	Half apertures X	Y (um)	σX	σY		TRC
SP1	300	250	18.5	326		
SP2	300	200	10.9	31		
AB2	1000	1000				
SP3	300	250	18.5	326		
AB3	1000	1000				
SP4	300	200	10.9	31		
AB4	1000	1000				
SP5	420	300	20.0	450		
AB5	1400	1000				
ESP	3200	3200	78.3	112		
EAB	1000	1000	23.6	193		
AB10	4400	4400	14.1	40	*	
AB9	6600*	3000	12.5	45		6500
AB7	4200*	1000	256	385		3900
DP1	8300*	20000				8000
DP2	8500	20000				

Sp1 ~ SP4 settings with OCT x2.5

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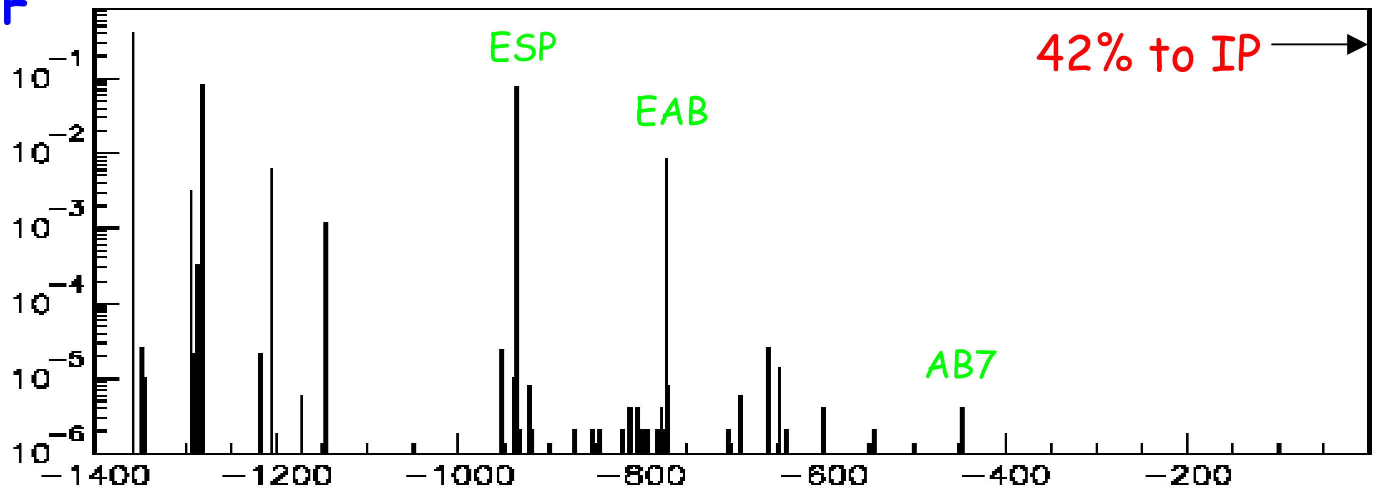
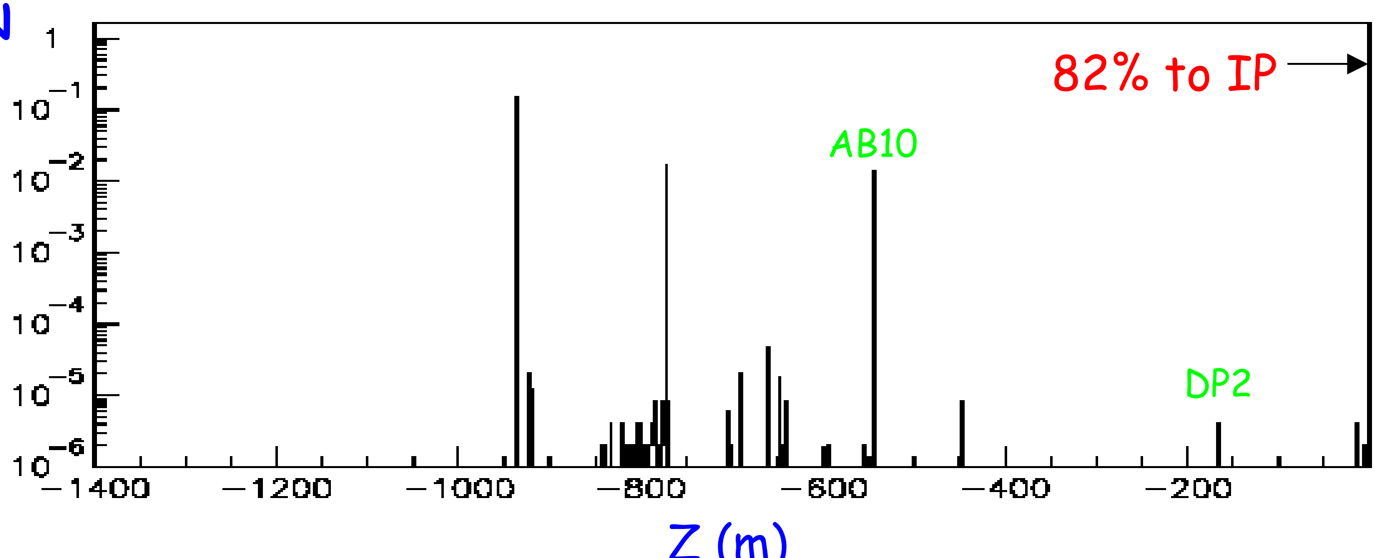
Particle loss distribution for TRC Halo Model

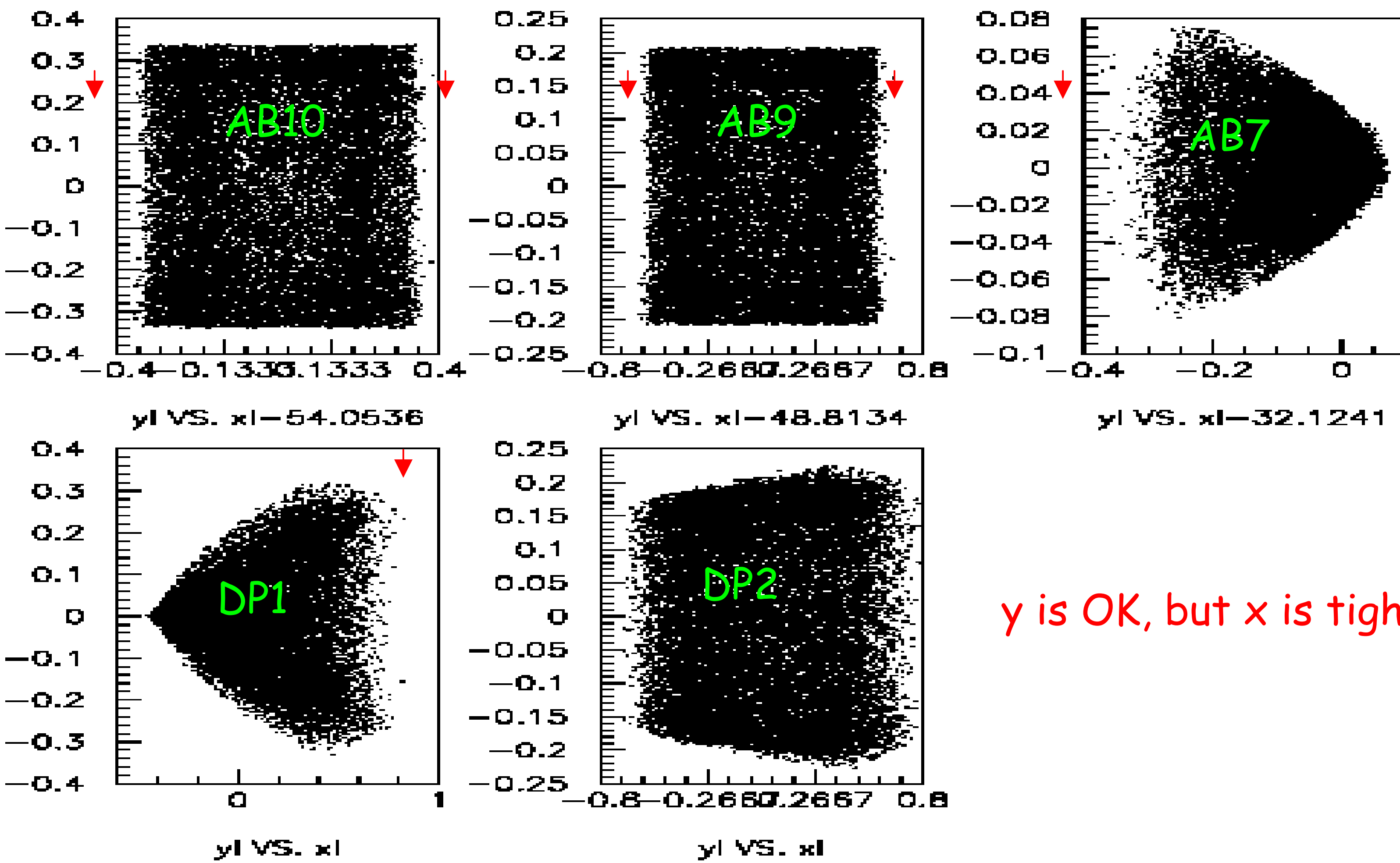
OCT-OFF



OCT-ON

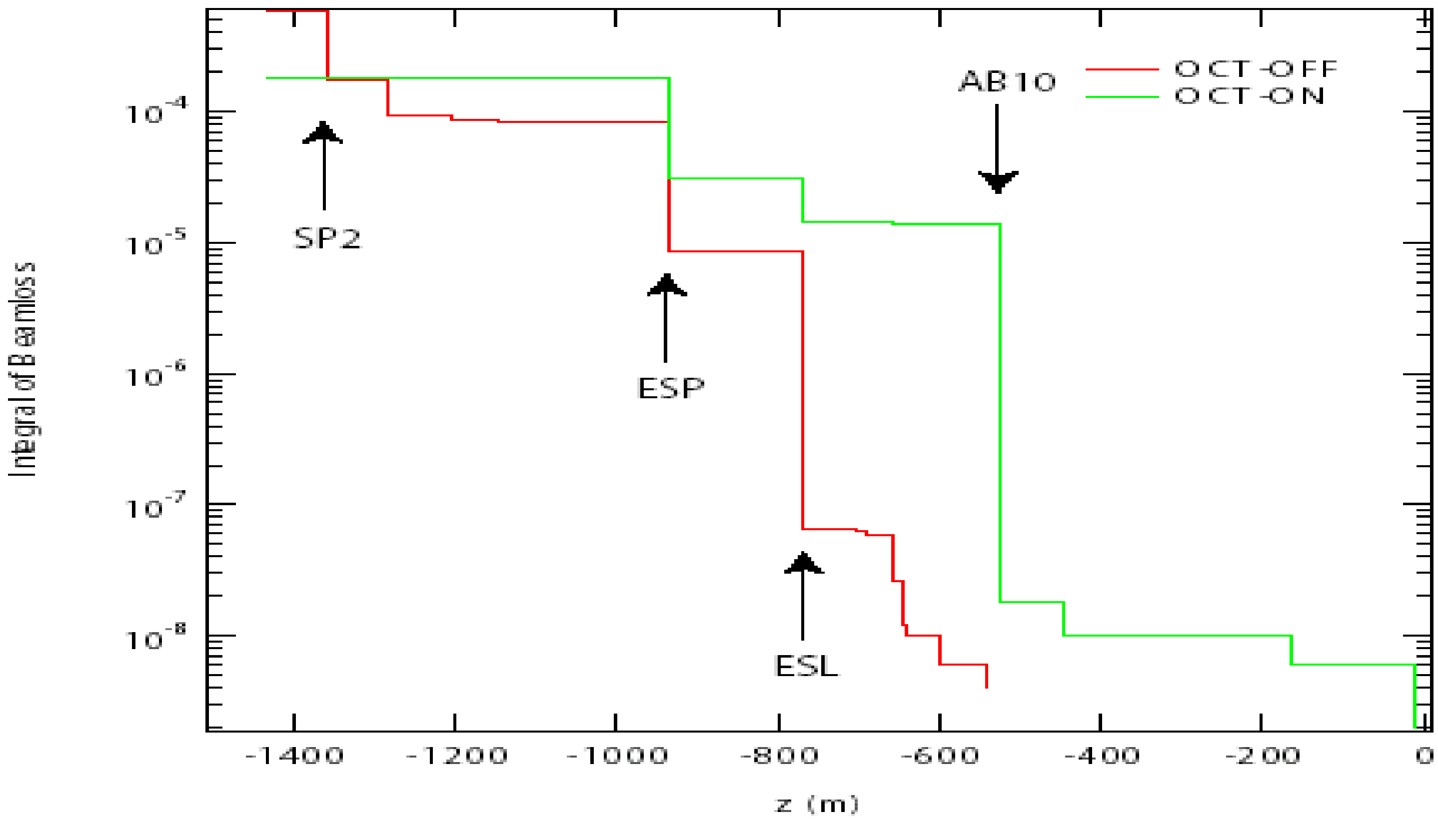


Particle distributions at FF absorbers

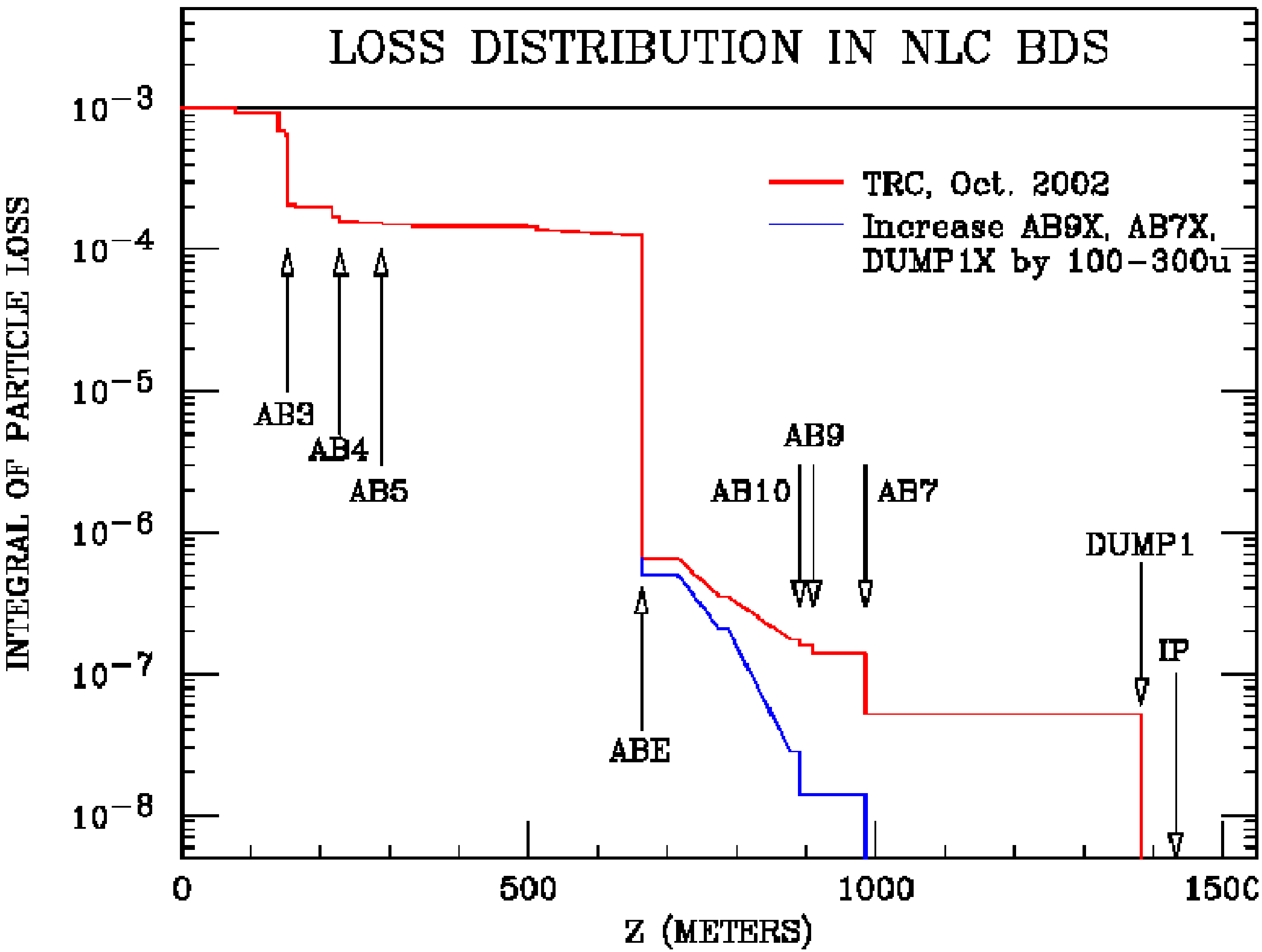


y is OK, but x is tight.

Integral Particle Loss Distribution



Efficiency of NLC Collimation System (Talk by Andrei Seryi)



E=250 GeV

N=1.4E12

0.1% Halo distributed as 1/X and 1/Y for $6<A_x<16\sigma_x$ and $24<A_y<73\sigma_y$ with $\Delta p/p=0.01$ gaussian distributed

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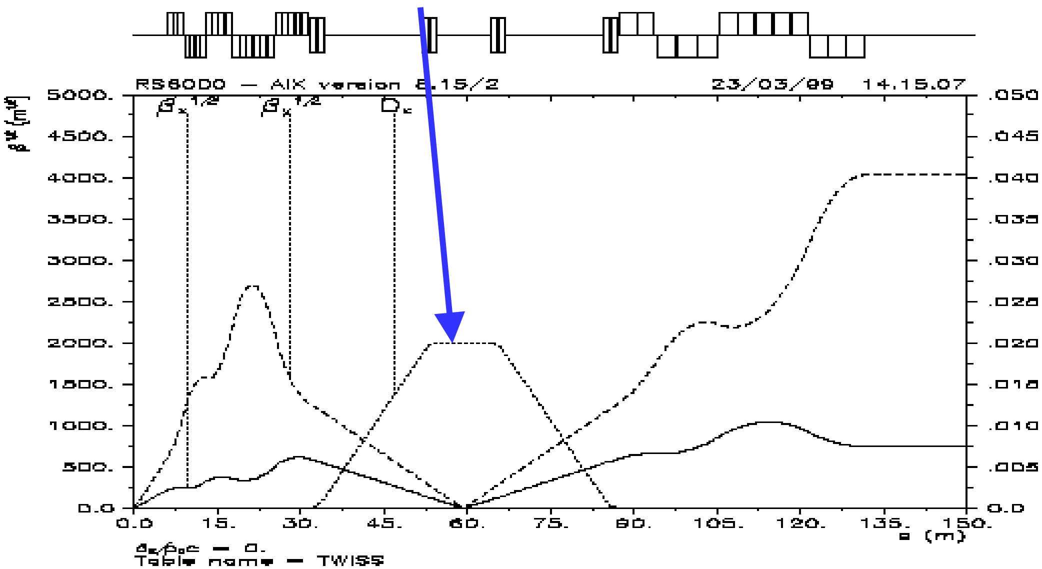
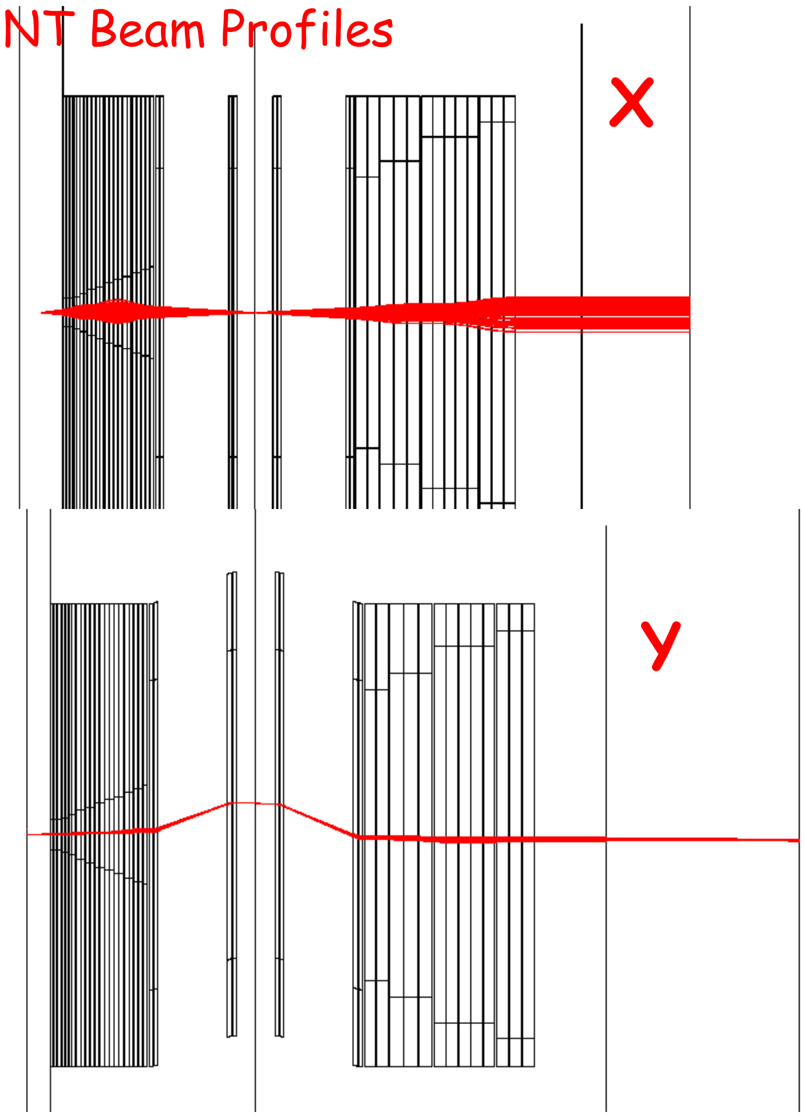
NLC Extraction Line

Y. Nosochkov et al. (SLAC-PUB-8096)

Compton IP: 2nd focus w/
20mm dispersion

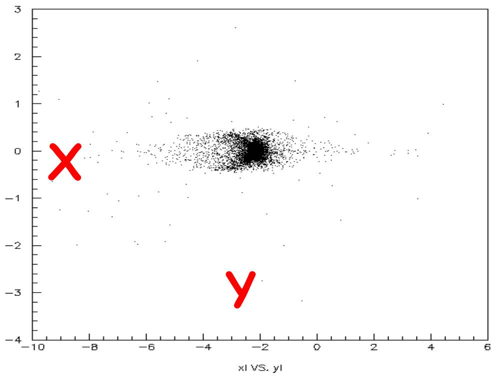


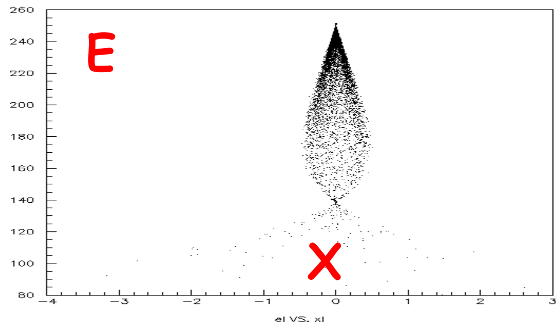
GEANT Beam Profiles

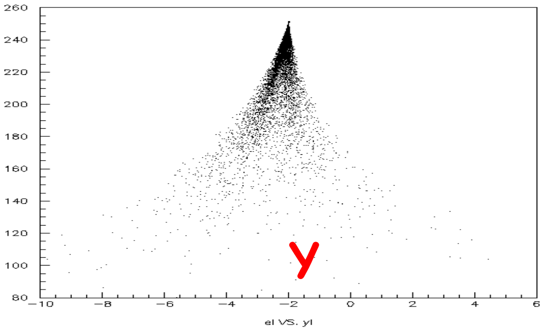


Ken Moffeit Begins to Design Energy Spectrometer & Polarimeter in GEANT3

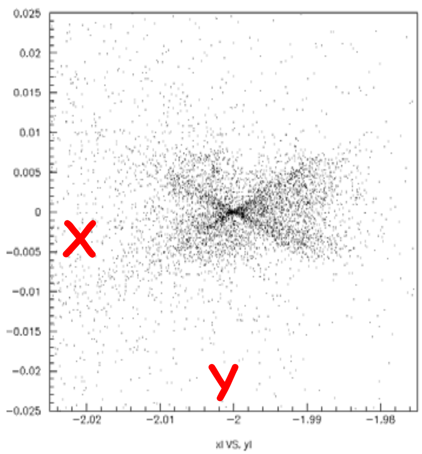
Distributions at mid-chicane

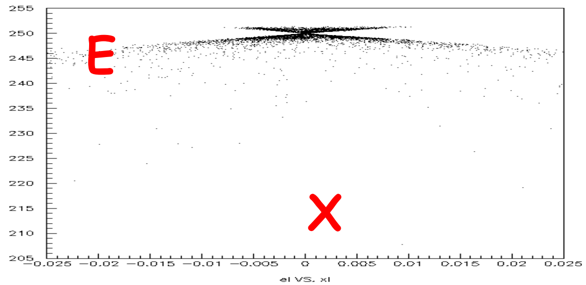


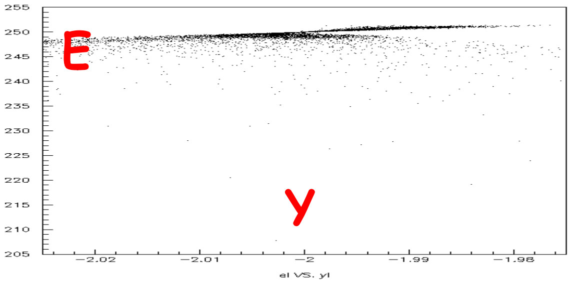




cut: |x|<0.025cm & |y+2|<0.025cm:
to correspond to area illuminated by laser







Example Analysis: Measure luminosity weighted depolarization at IP vs. laser-weighted depolarization in chicane due to spin-diffusion

Conclusions

- It is becoming recognized in the experimental HEP user community that optimizing luminosity, backgrounds, etc. for a linear collider is as valid a contribution as developing a marginally better tracker
- GEANT-based beam analysis is a relatively easy way to merge physicists so inclined into the machine design process
- Excellent agreement when benchmarked against other programs during spoiler & beam-gas studies
- Ken's comment:
  "Using GEANT for beam studies is user friendly"

GEANT4

- Use for machine development actively pursued by Graham Blair
  - Results presented at various conferences
  - Handles muons
  - Obviously the future, but too close to bleeding edge for us for now
- Full package up & running for JLC by U. of Tokyo group
  - H. Aihara, M. Iwatsaki & K. Tanabe
- Detailed comparison with GEANT3 in progress
  - Still not user friendly enough to produce corresponding distributions
  - Still on the steep part of GEANT4 learning curve